DEPARTMENT OF THE INTERIOR

POCS REFERENCE PAPER NO. 53-2

Oil Spill Risk Analysis

Of Proposed OCS Sale No. 53

Central And Northern California

Prepared by the Bureau of Land Management, Pacific OCS Office
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ERRATA SHEET

POCS Reference Paper No. 53-2 - Oil Spill Risk Analysis

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TABLE 8

CONDITIONAL PROBABILITY OF OIL SPILL IMPACT AS A FUNCTION OF TRACTS

Note: Assuming that an oil spill does take place in a given area (P, etc.), the probability of impact is shown within:

top - 3 days
lower left-10 days
lower right-30 days

Note: All numbers indicate probability in percent.

Resource Category	Shoreline Segment	Shoreline Segment No.	Eel River P1	Eel River P2	Pt. Arena P3	Bodega P4	Santa Cruz P5	Santa Cruz P6	Santa Cruz P7	Santa Maria P8	Santa Maria P9	Santa Maria P10	Santa Maria P11	Santa Maria P12
Shoreline Segment	Farallon Island	15	0	0	0 0 | 2	1 13 | 15	2 13 | 19	0 7 | 13	0 5 | 11	0	0	0	0	0
	San Mateo County	17	0	0	0 0 | 1	0 2 | 6	1 11 | 12	7 15 | 15	0 1 | 1	0	0	0	0	0
	San Mateo County	18	0	0	0	0 4 | 10	10 28 | 36	24 46 | 49	2 16 | 23	0	0	0	0	0
	Santa Cruz County	19	0	0	0	0 0 | 1	3 7 | 8	1 3 | 4	4 14 | 19	0	0	0	0	0
	San Luis Obispo County	25	0	0	0	0	0	0	0	2 6 | 6	0 2 | 3	0 2 | 4	0 1 | 3	0 1 | 4	0
	San Luis Obispo County	26	0	0	0	0	0	0	0	6 9 | 11	0 1 | 2	1 7 | 9	0 1 | 2	0 3 | 7	0
	Santa Barbara County	27	0	0	0	0	0	0	0	1 4 | 6	0 0 | 1	1 3 | 3	0	0	0
	San Miguel Island	40	0	0	0	0	0	0	0	0 4 | 7	0 7 | 8	0 10 | 11	0 7 | 8	0 13 | 14	0
	Santa Rosa Island	41	0	0	0	0	0	0	0	0	0	0	0	0 0 | 1	0
	Santa Cruz Island	42	0	0	0	0	0	0	0	0	0	0	0	0	0
	Anacapa Island	43	0	0	0	0	0	0	0	0	0	0	0	0	0
	Catalina Island	47	0	0	0	0	0	0	0	0	0	0	0	0	0
	Rodriquez Seamount		0	0	0	0	0	0	0	0 0 | 1	0 1 | 4	0 0 | 1	0 3 | 4	0 1 | 2	0
	Gulf of the Farallons		0	0	0 1 | 3	5 25 | 27	6 25 | 28	2 14 | 17	0 12 | 19	0 0	0	0	0	0	0
	Sea Otter Range		0	0	0	0 0 | 1	0 0 | 1	0	0 9 | 11	30 34 | 35	1 8 | 13	1 7 | 12	0 4 | 12	0 2 | 9	0
	Richardson Rock		0	0	0	0	0	0	0	0 9 | 14	0 9 | 11	0 15 | 19	0 10 | 12	4 19 | 22	0
	Wilson Rock		0	0	0	0	0	0	0	0 3 | 4	0 6 | 7	0 9 | 9	0 6 | 6	0 10 | 11	0
	Tanner Bank		0	0	0	0	0	0	0	0 0 | 7	0 0 | 11	0 0 | 9	0 0 | 11	0 1 | 10	0
	Cortes Bank		0	0	0	0	0	0	0	0 0 | 10	0 0 | 14	0 0 | 9	0 1 | 15	0 1 | 11	0
	Commercial Shellfish		20 47 | 67 100	76 83 | 89 100	49 61 | 66 16	33 56 | 66 37	73 76 | 77 87	70 71 | 72 100	3 25 | 34 30	83 89 | 91 100	41 53 | 65 9	43 62 | 70 79	5 26 | 46 2	4 36 | 54 6	
	General Sportsfishing		100 | 100	100 | 100	21 | 27	59 | 69	98 | 99	100 | 100	77 | 89	100 | 100	31 | 58	83 | 89	24 | 57	36 | 61	

PREFACE

Oil spill risk analysis is a complicated process requiring many types of input that appear in several different places in the Environmental Impact Statement and other reference documents. This paper provides information to the Sale No. 53 EIS reader who desires more detailed information on the oil spill analysis, but does not have the time or resources to obtain the required supplementary data. It was prepared by Thomas S. Cooke, a physical scientist and staff person who coordinated and accomplished much of the analysis herein.

ABSTRACT

The risk of potential oil spills from proposed oil and gas leases has become an integral part of environmental analysis. The proposed tracts selected for analysis for OCS Sale No. 53 off the central and northern California Coast were evaluated, along with the projected transportation routes, using an oil spill risk analysis model developed by the Department of the Interior. Potential targets in the form of shoreline segments, and key resource areas of special interest were evaluated to determine potential risk.

INTRODUCTION

The Department of the Interior Oil Spill Risk Analysis Model has been described[1]. The detailed model results can be obtained from the U.S. Geological Survey[2]. In addition to these documents, a great deal of Outer Continental Shelf (OCS) related oil spill information related to oil and gas development offshore can be obtained from the Environmental Impact Statement published for OCS Sale No. 48[3]. The following data is provided as a synopsis of critical information for those that have neither the time nor the resources to obtain the above three references.

DESCRIPTION OF THE OIL SPILL RISK ANALYSIS MODEL

The oil spill risk analysis model was developed by members of the U.S. Geological Survey located in Reston, Virginia. To analyze potential targets, the area to be studied is plotted, using a digitizing

process, on a 480 by 480 cell grid. The 12 representative oil spill launch areas (P1 through P12) selected for Sale No. 53 were then plotted as shown on Figure 1. Potential oil spill launch areas representative of existing development (E1 through E5) were also plotted as shown on Figure 2 for determining cumulative impacts. Potential transportation routes (both tanker and pipeline) were also plotted as shown on Figure 3.

To provide flexibility in analyzing shoreline impacts such as beaches, harbors, marinas, kelp beds, etc., the shoreline is divided into segments as shown on Figure 4. Each segment is approximately 27 miles long. Islands are also represented in this manner. Once a spill impacts a shoreline segment, the computer run is terminated. Potential resource categories to be evaluated that do not lie within a shoreline segment are plotted as shown in Figures 5, 6, and 7. While analyzing the "at-sea" resource categories, the evaluator must remember that the relative size of the area will affect the numerical results. For example, the area represented by the Guide Seamount on Figure 5 is significantly less (and, therefore, represents less of a target) than that of the commercial shellfish area shown on Figure 6. Also, the commercial shellfish area is on the bottom and will suffer a different type of impact from oil spills than a beach or other shoreline target. The computer is also programmed to treat "at-sea" resource impacts differently. A "hit" is registered, but the spill trajectory is not terminated and keeps on going until it either impacts a shoreline segment or is terminated after 30 days.

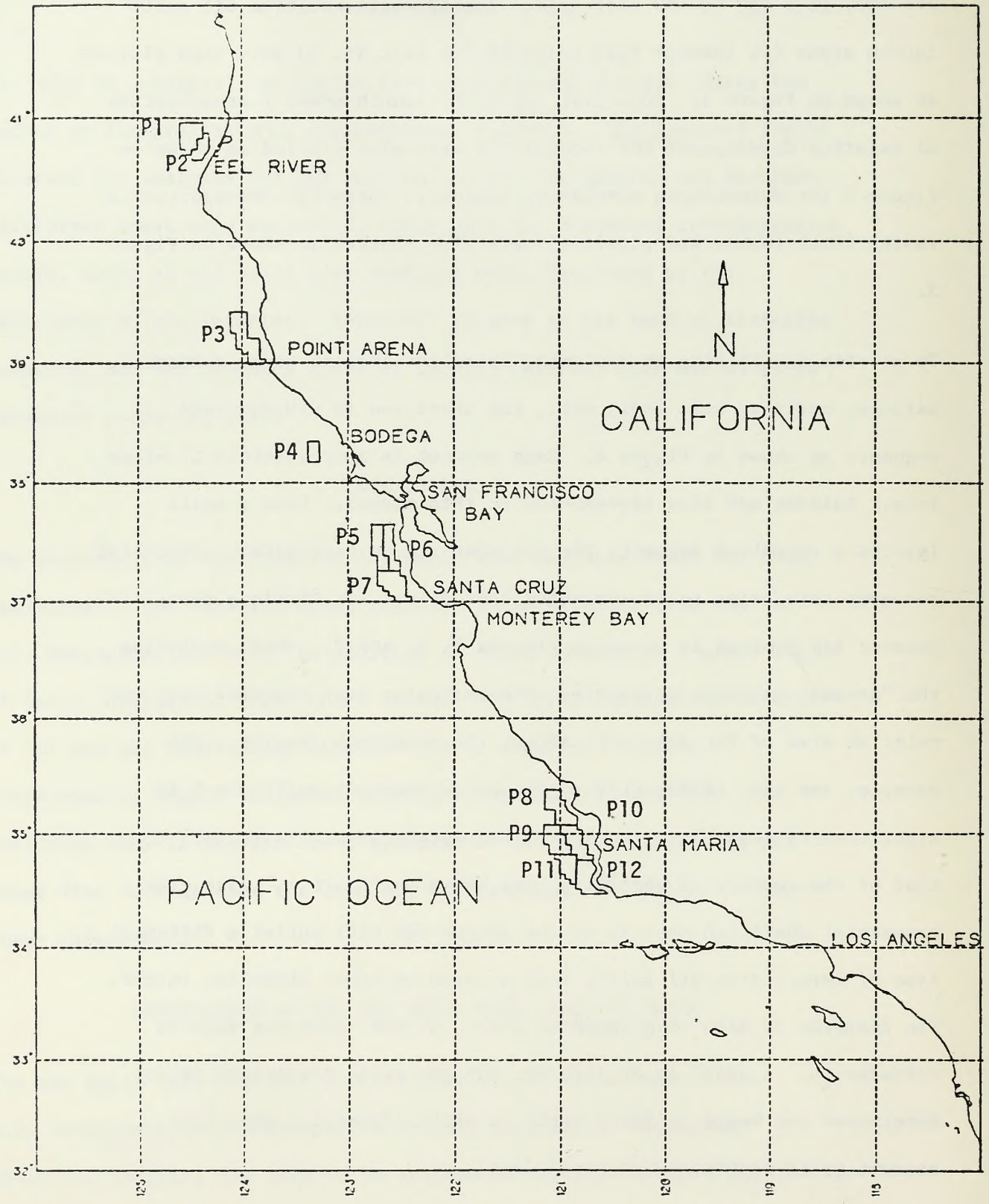

Figure 1 --Map showing subdivisions of the proposed leases for Central and Northern California OCS Lease Sale 53.

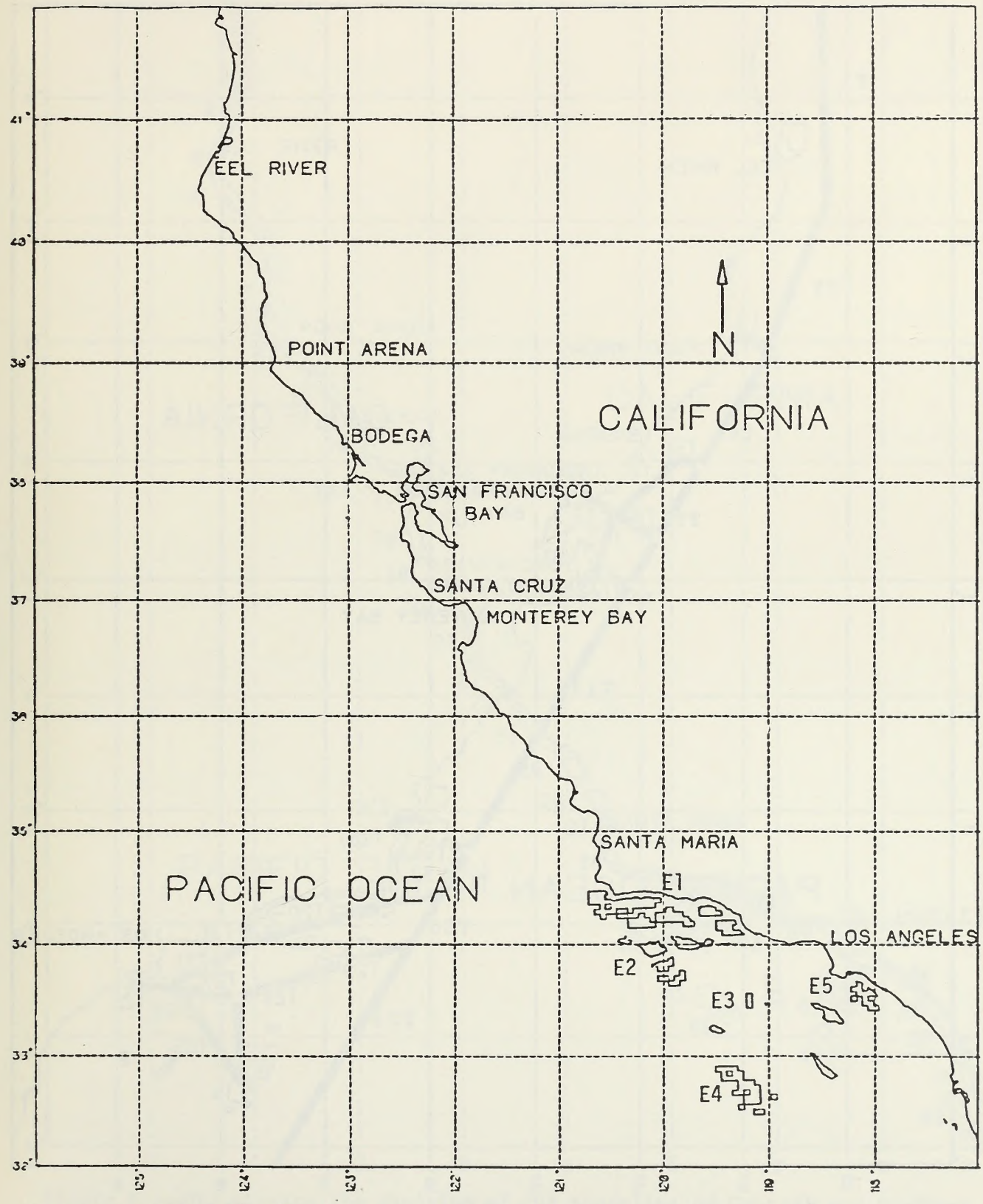

Figure 2 --Map showing the subdivisions of the existing leases in the study area.

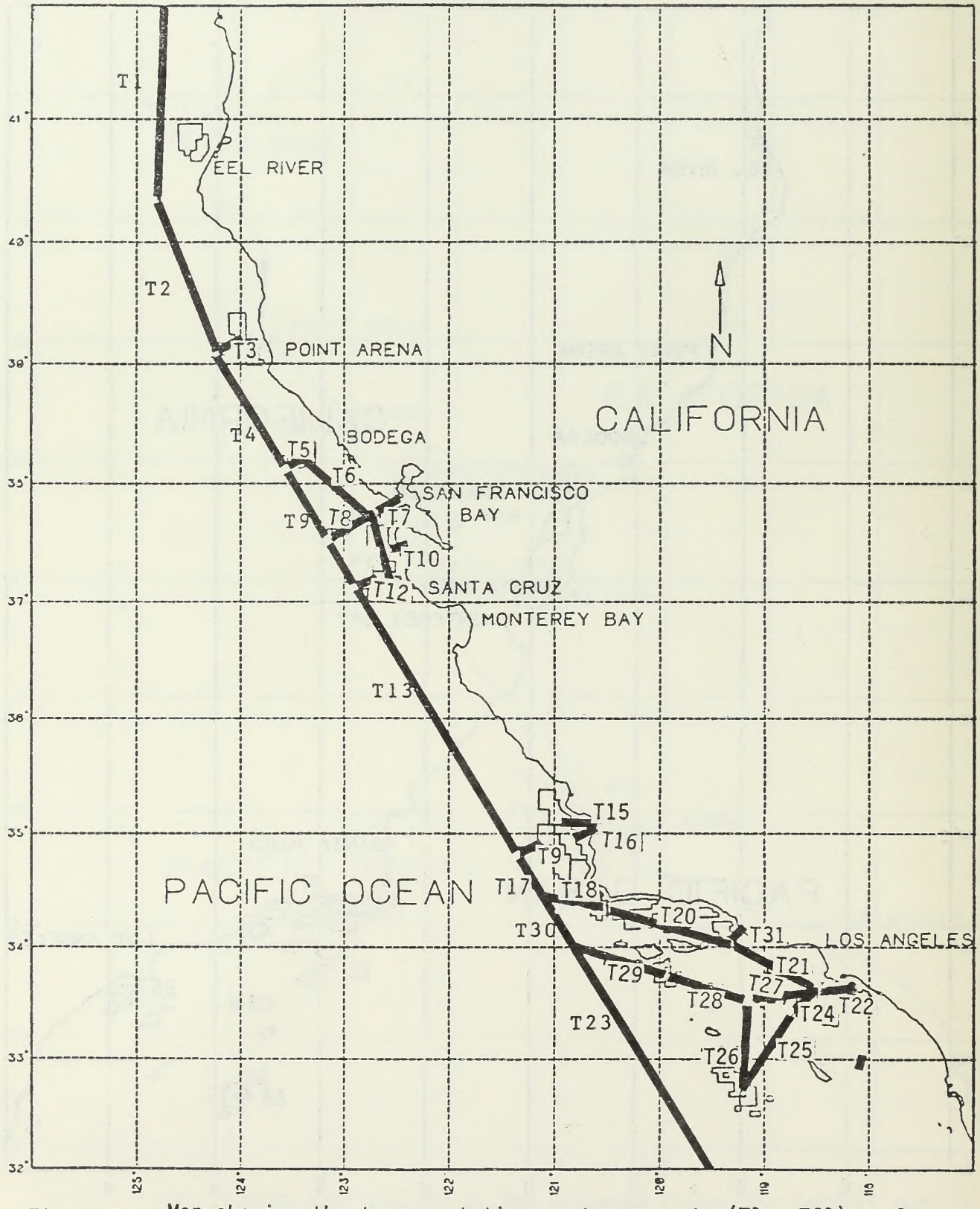

Figure 3 --Map showing the transportation route segments (T1 - T31); polygons represent proposed and existing lease tracts.

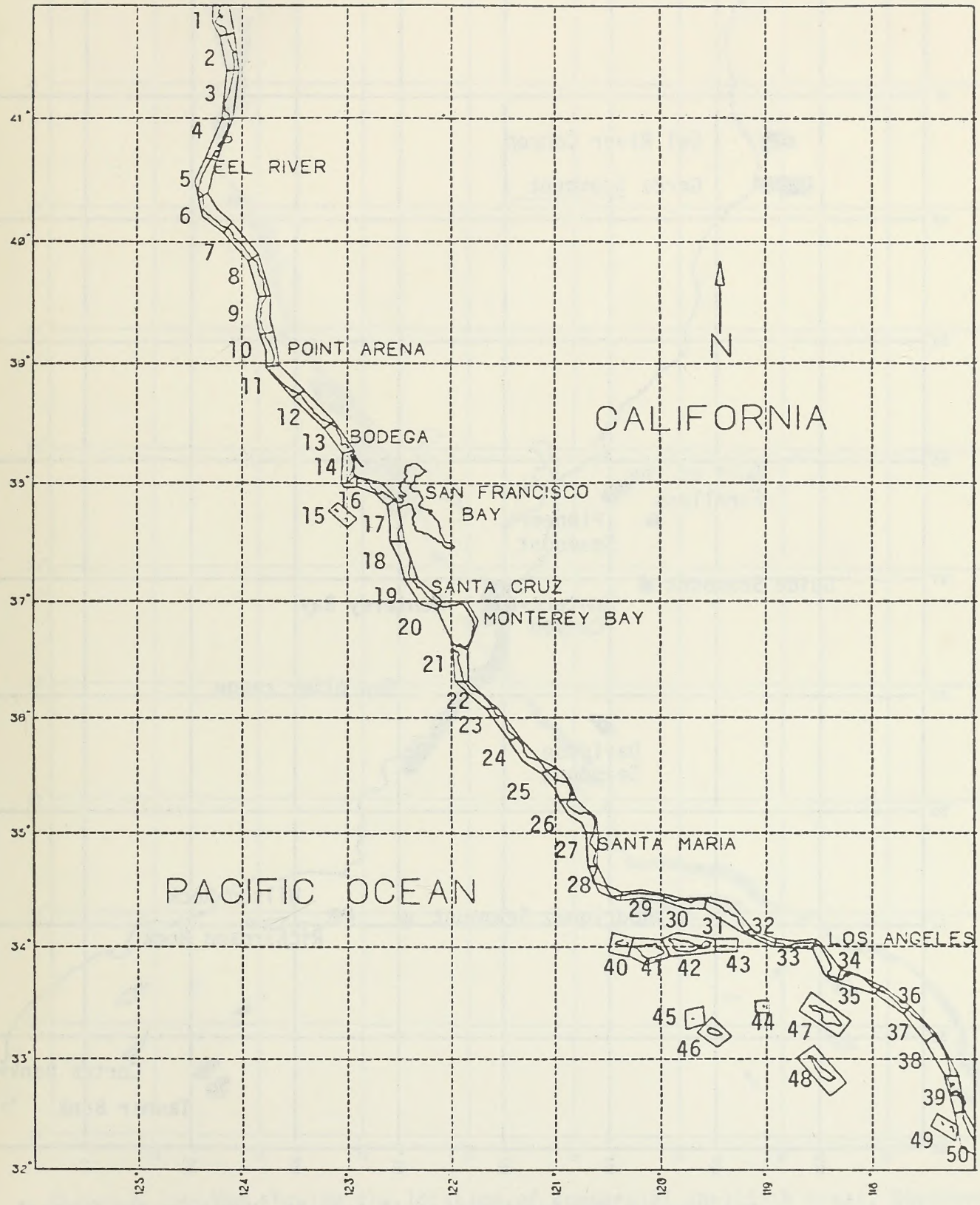

Figure 4 --Map showing the division of the shoreline of Central and Northern California into segments of approximately equal length.

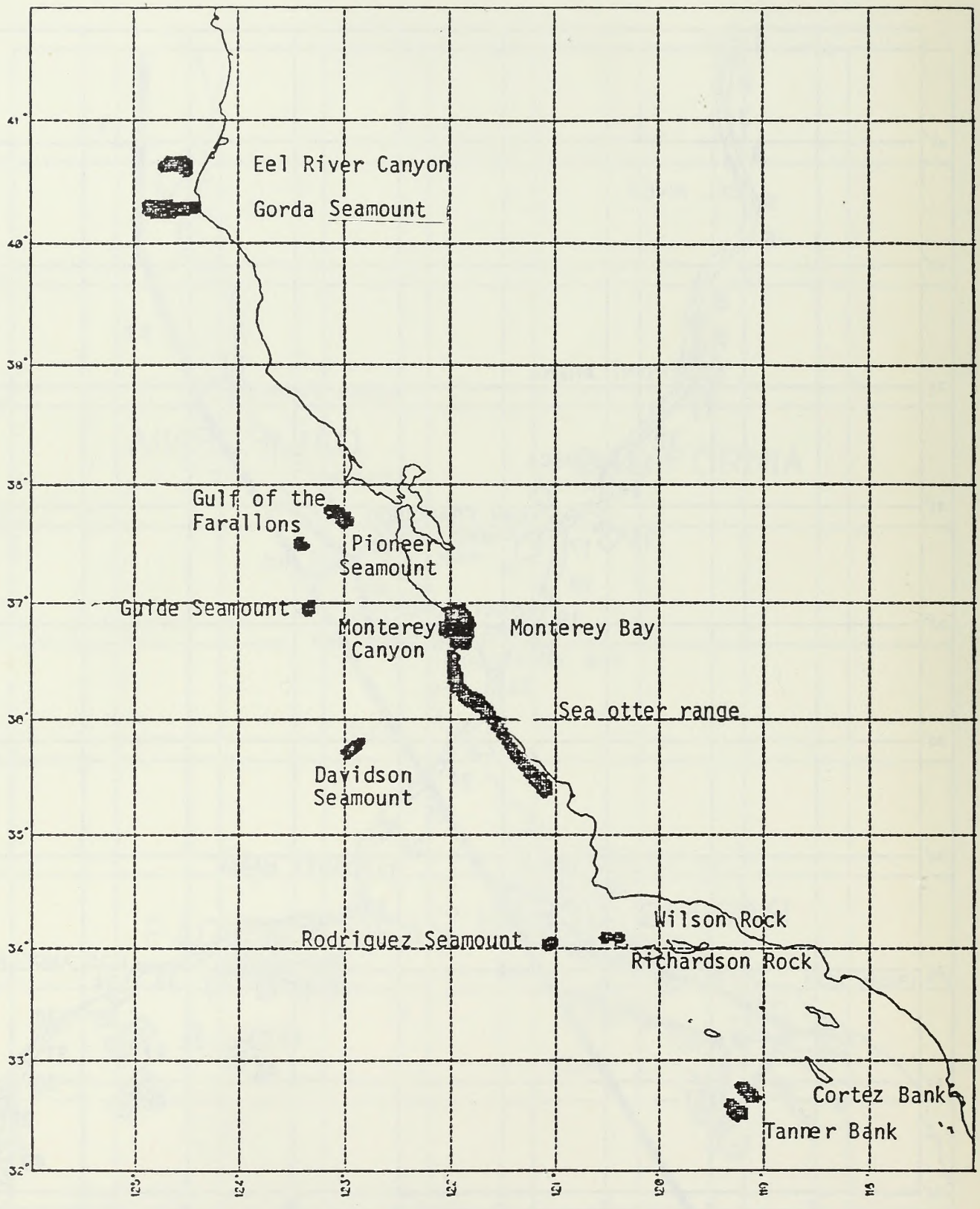

Figure 5 -- Map showing the locations of 14 targets, Northern and Central California OCS Lease Sale 53: cross hatching indicates areal extent of targets.

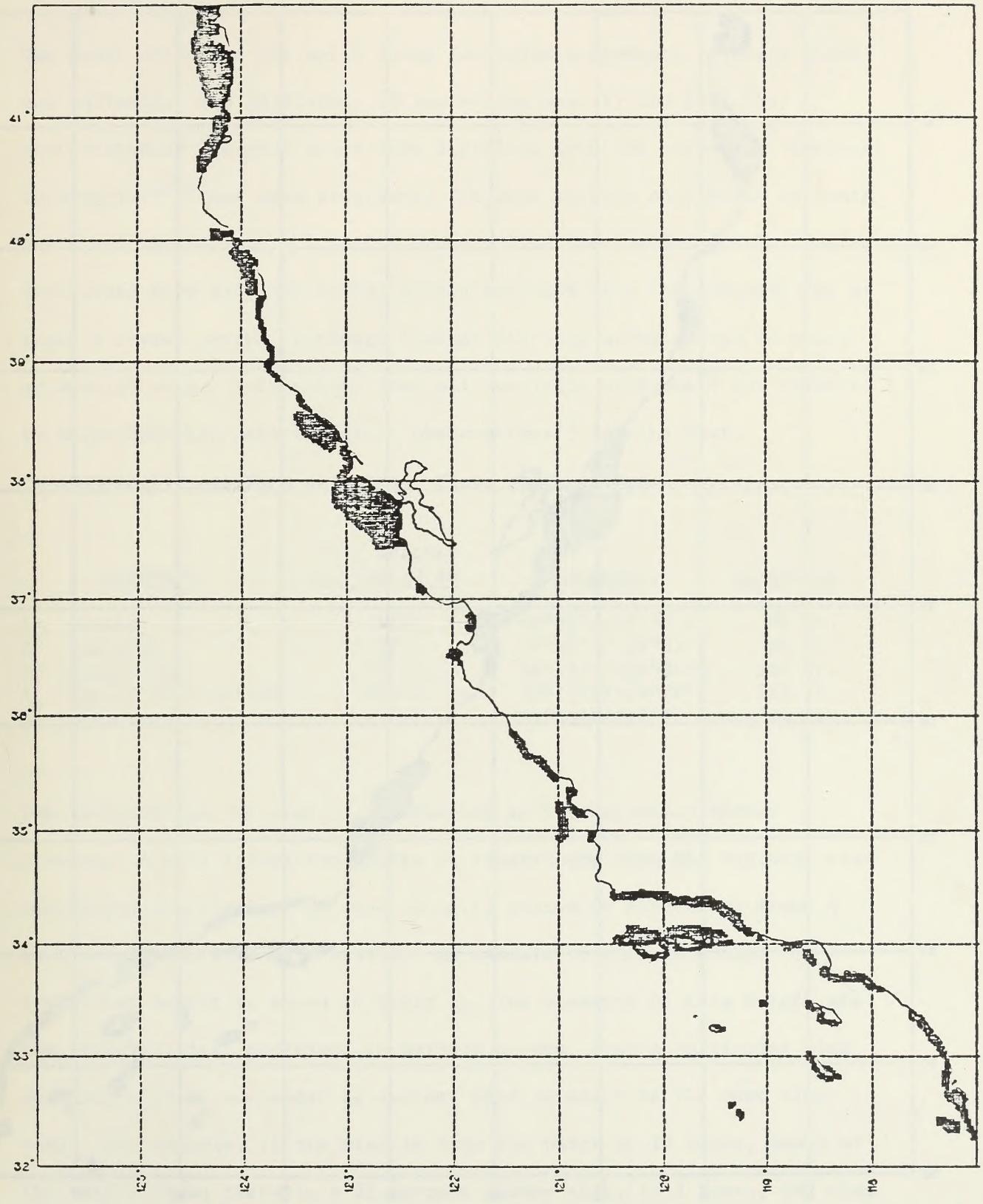

Figure 6 -- Map showing the location of commercial shellfish areas, Northern and Central California OCS Lease Sale 53: cross hatching indicates areal extent of commercial shellfish areas.

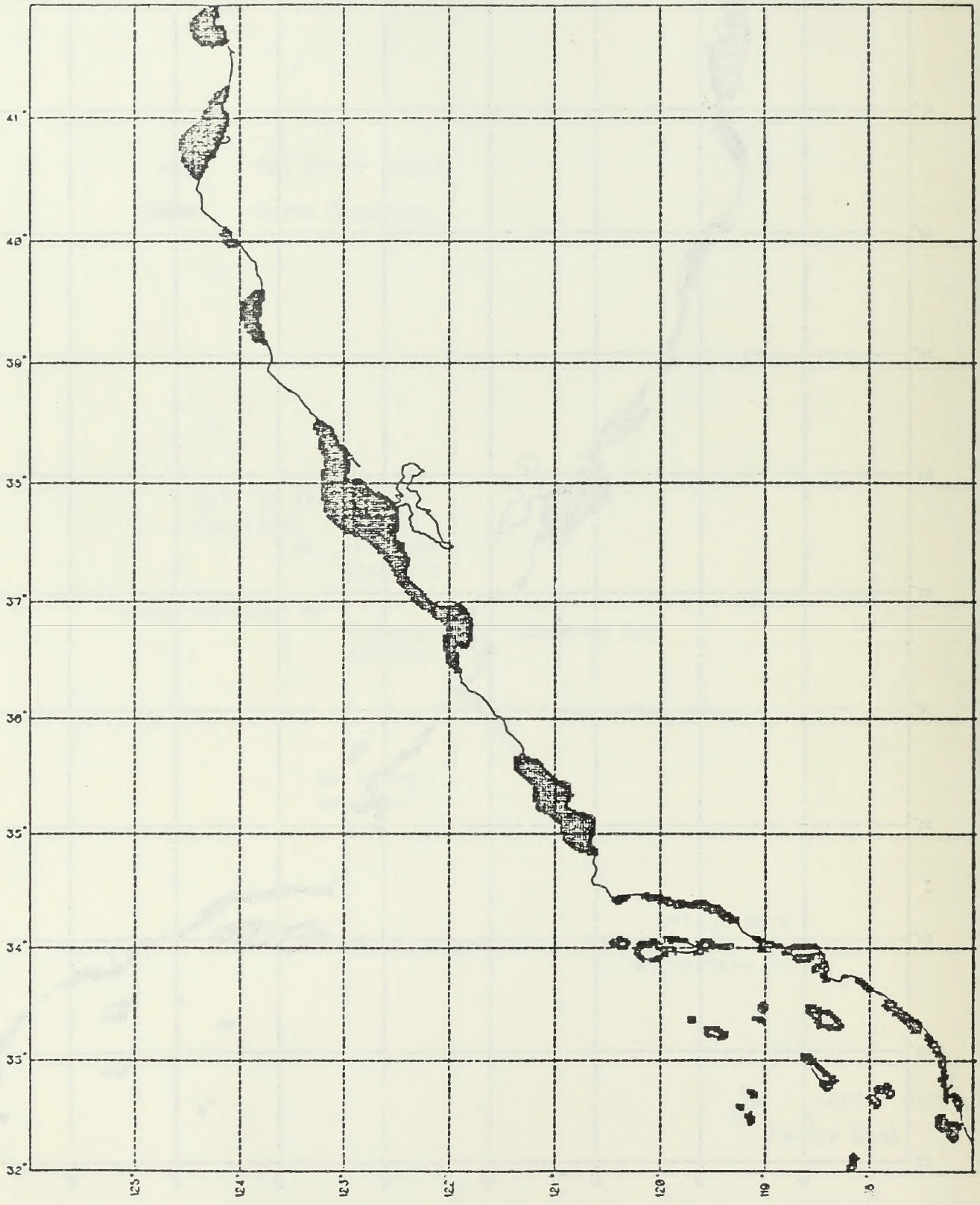

Figure 7 -- Map showing the location of general sportfishing areas, Northern and Central California OCS Lease Sale 53: cross hatching indicates areal extent of general sportfishing areas.

The model drives an oil spill using two basic parameters, surface winds and currents. The California offshore area was divided into 785 representative polygons which were digitized into the computer. Current information[4-11] was then programmed for each polygon on a month by month basis and ranged from 0.1 to 0.5 knots. Wind speed and direction was determined from stations having hourly recorded data continuously for at least a 5-year period, although typical stations selected had 20 years or more of data. Information from all available stations[12] was compared to ships Synoptic Meteorological Observations[13] and the most representative stations selected. These stations are:

Location	U.S. Weather Service ID No.	Location	Elevation
1. Arcata	24283	40°59'N/124°6'W	69 ft.
2. Monterey	23245	36°36'N/121°51'W	50 ft.
3. Vandenberg	93214	34°43'N/120°34'W	116 ft.
4. San Nicolas Island	93116	33°15'N/119°28'W	153 ft.
5. San Diego	93112	32°43'N/117°12'W	15 ft.

The variation in the wind is represented as a first-order Markov process. A wind transition matrix is constructed from the historic wind record and provides for 41 wind velocity states (8 directions times 5 speed classes plus a calm state). An example of part of a wind transition matrix is shown in Table 1. The elements of this matrix are the probabilities, expressed in percent chance, that a particular wind velocity will be succeeded by another wind velocity in the next time step. For example, if the wind is from the north at 10 knots, Row 3 of the matrix shows there is a 22 percent chance that, in 3 hours, the wind

TABLE 1

EXAMPLE OF A PORTION OF A 3-HOUR WIND TRANSITION PROBABLITY MATRIX.

Probability of wind velocity class for next three-hour period, expressed as percent chance.

Present velocity class		Direction: CALM	N				NE			
		Speed:	5	10	15	25	5	10	15	25
DIR	SPD									
CALM	0	27	2	1	0	0	3	0	0	0
N	5	28	10	13	1	0	6	1	0	0
N	10	10	15	22	6	0	9	1	0	0
N	15	6	0	11	0	0	0	0	0	0
N	20	50	0	50	0	0	0	0	0	0
N	25	0	0	0	0	0	0	0	0	0
NE	5	26	6	1	0	0	9	1	0	0
NE	10	22	0	22	0	0	0	0	0	0
NE	15	0	0	**	0	0	0	0	0	0
NE	20	0	0	0	0	0	0	0	0	0
NE	25	0	0	0	0	0	0	0	0	0

* Indicates greater than 99 percent probability.

will still be from the north at 10 knots, and that there is a 9 percent chance it will be from the northeast at 5 knots. If the present state of the wind is given, then the next wind state is chosen by randomly sampling according to the percentages given in the appropriate row of the matrix.

Once the targets, winds and currents have been identified and a set of potential oil spill launch points has been chosen to represent the places where oil spills could occur due to OCS production or oil transportation (Figures 1, 2, and 3), the hypothetical oil spill trajectories can be simulated. From each of the launch points, the model simulates, in a Monte-Carlo fashion, 500 hypothetical trajectories per season for a total of 2,000 per year (for each potential launch point). The movement of each simulated oil spill is determined, in 3-hour increments, as the sum of a current vector and a wind vector. The current vector is determined by the spill's location and the simulated month; the wind vector is selected by sampling the wind transition probability matrix of the appropriate wind zone and season and was set equal to 3.5 percent of the wind velocity, and rotated 20 degrees clockwise to account for Coriolis effects. Each grid cell through which the spill passes is checked for the presence of land or targets, and contacts are recorded. Simulation of an oil spill ceases when it: 1) contacts land, 2) moves beyond the limits of the base map, or 3) continues beyond 30 simulated days.

By examining data from the trajectory simulations, the model calculates

the probability that, if an oil spill occurs at a given launch point, it will contact a particular target or land segment within 3, 10, or 30 days. The three time periods were chosen to represent various milestones during an oil spill:

3 days - While most of the toxic fractions of the oil will evaporate or dissolve along with the 50 percent of crude oil that normally disappears within the first 24 hours of release, frequently the oil spill will not have moved very far. Three days were selected as allowing for the oil spill to have moved a reasonable distance, but still dealing with freshly weathered oil.

10 days - Sufficient time for cleanup measures from nearby oil spill cooperatives, contractors, etc., to have been employed.

30 days - The oil spill will probably not be detectable if still at sea.

Assessment of oil spill risks requires both the conditional probabilities showing where a spill will go if it occurs, and the probability of oil spills occurring in the first place. In this model, oil spill occurrence is treated as a Poisson process, in which the exposure variable is the volume of oil produced or transported. The parameters for this probability distribution are determined from historic accident rates for platforms, pipelines and oil tankers, as shown in Table 2.

TABLE 2

HISTORIC OIL SPILL OCCURRENCE RATES USED IN MODEL
(Spills over 1,000 barrels)

Spill Source	No. of Spills	Volume Handled (millions of bbls)	Data Source	Area Covered	Time Period Covered
Platforms	7	3,900	USGS accident files	U.S.	1964-78
Pipelines	11	4,780	Stewart (1975, p. 32) and personal communication May, 1977	U.S.	1964-75
Tankers	178	45,941	Stewart (1976, p. 66)	Worldwide	1969-73

TABLE 3

HISTORIC OIL SPILL OCCURRENCE RATES OF SPILLS
OF LESS THAN 1,000 BARRELS

Platform: 0.000045/BBL produced
Pipeline: 0.000015/BBL produced
Tanker: 0.000346/BBL produced

TABLE 4

RISKED MEAN OIL ESTIMATES
(millions of bbls)

Eel River	0	(P_1 P_2)
Point Arena	25	(P_3)
Bodega	8	(P_4)
Santa Cruz	113	(P_5, P_6, P_7)
Santa Maria	402	(P_8, P_9, P_{10}, P_{11}, P_{12})
Total	548	
Santa Barbara Channel	728	(E1)
Santa Rosa Island	10	(E2)
Santa Barbara Island	15	(E3)
Tanner/Cortes Banks	181	(E4)
San Pedro	166	
Total	1,100	

Spill statistics under 1,000 bbls are difficult to evaluate historically because of the manner in which the data was recorded and the discrepancies between the data collected by different agencies. Based on the Gulf of Mexico statistics, BLM selected the data shown in Table 3 for use in OCS Sale No. 35[14] and which has been used in subsequent sales.

The risk of an oil spill caused by seismic activity has been assumed to be zero as there has never been an oil spill caused because of seismic activity. This includes the Santa Barbara Channel which has a long history of oil development and also several earthquakes that have occurred, some recently.

As a basis for determining the potential of an oil spill, the following risked mean oil estimates (Table 4) were used for the potential launch points shown in Figures 1 and 2.

Using the data in Table 4, the statistical potential number of spills was calculated for each area for the three transportation scenarios defined in the Sale No. 53 Environmental Impact Statement and further explained in Reference Paper No. 53-1. The values are shown in Tables 5 and 6.

As discussed earlier, the computer model was run assuming that a spill had occurred and showing potential places and categories of impact. The existing projected development, as shown in Figure 2, is listed in Table 7. Potential launch points, as shown in Figure 1, are shown in Table 8. Transportation routes, as shown in Figure 9, are shown in

TABLE 5

POTENTIAL NO. OF OIL SPILLS OF 1000 BBL'S OR GREATER

Scenario 1: Pipelines and Tankering to California Refineries

Area	Platform	Pipeline	Tanker	Total
Point Arena	0.04	0	0.05	0.09
Bodega	0.01	0	0.08	0.09
Santa Cruz	0.20	0.26	0	0.46
Santa Maria	0.72	0.93	0	1.65
Sale No. 53	0.97	1.19	.13	2.29

Scenario 2: 100% Tankering to California Refineries

Area	Platform	Pipeline	Tanker	Total
Point Arena	0.04	0	0.05	0.09
Bodega	0.01	0	0.08	0.09
Santa Cruz	0.20	0	1.22	1.42
Santa Maria	0.72	0	0.78	1.50
Sale No. 53	0.97	0	2.13	3.10

Scenario 3: 100% Tankering to Gulf Coast Refineries

Area	Platform	Pipeline	Tanker	Total
Point Arena	0.04	0	0.05	0.09
Bodega	0.01	0	0.08	0.09
Santa Cruz	0.20	0	0.11	0.31
Santa Maria	0.72	0	0.89	1.61
Sale No. 53	0.97	0	1.13	2.10

TABLE 6

POTENTIAL NO. OF OIL SPILLS UNDER 1000 BBL'S

Scenario 1: Pipelines and Tankering to California Refineries

Area	Platform	Pipeline	Tanker	Total
Point Arena	3.47	0	11.05	14.52
Bodega	1.12	0	3.54	4.66
Santa Cruz	15.81	15.81	0	31.62
Santa Maria	56.24	56.24	0	112.48
Sale No. 53	76.64	72.05	14.59	163.28

Scenario 2: 100% Tankering to California Refineries

Area	Platform	Pipeline	Tanker	Total
Point Arena	3.47	0	5.52	8.99
Bodega	1.12	0	9.06	10.18
Santa Cruz	15.81	0	49.94	65.75
Santa Maria	56.24	0	88.83	145.07
Sale No. 53	76.64	0	153.35	229.99

Scenario 3: 100% Tankering to Gulf Coast Refineries

Area	Platform	Pipeline	Tanker	Total
Point Arena	3.47	0	2.76	6.23
Bodega	1.12	0	4.53	5.65
Santa Cruz	15.81	0	24.97	40.78
Santa Maria	56.24	0	44.42	100.66
Sale No. 53	76.64	0	76.68	153.32

[a]Statistics are only available for the joint category of platform and pipeline spills. It has been assumed that there is a 50-50 split between pipeline and platform related spills in this table.

TABLE 7

CONDITIONAL PROBABILITY OF OIL SPILL IMPACT AS A FUNCTION OF EXISTING DEVELOPMENT

Note: Assuming that an oil spill does take place in a given area (E1, etc.) the probability of impact is shown within:

top - 3 days
lower left - 10 days
lower right - 30 days

Note: All numbers indicate probability in percent.

Shoreline Segment	Shoreline Segment No.	Santa Barbara Channel E1	Santa Rosa Island E2	Santa Barbara Channel E3	Tanner/ Cortes Banks E4	San Pedro E5
San Mateo County	17	0	0	0	0	0
San Mateo County	18	0	0	0	0	0
Santa Cruz County	19	0	0	0	0	0
San Luis Obispo County	25	0	0	0	0	0
San Luis Obispo County	26	0	0	0	0	0
Santa Barbara County	27	0	0	0	0	0
Farallon Island	15	0	0	0	0	0
San Miguel Island	40	6 8 | 9	0 1 | 1	0	0	0
Santa Rosa Island	41	6 11 | 12	2 3 | 3	0 2 | 3	0	0 0 | 1
Santa Cruz Island	42	21 30 | 32	0	0 0 | 1	0	0 0 | 1
Anacapa Island	43	8 11 | 12	0 0 | 1	0 0 | 1	0	0 0 | 1
Catalina Island	47	0 0 | 1	0 1 | 5	0 6 | 11	0 0 | 2	1 13 | 15
Rodriquez Seamount		0 0 | 1	0 0 | 1	0	0	0
Gulf of the Farallons		0	0	0	0	0
Sea Otter Range		0 0 | 1	0	0	0	0
Richardson Rock		7 9 | 10	0 0 | 1	0	0	0
Wilson Rock		7 9 | 10	0	0	0	0
Tanner Rock		0 0 | 2	0 3 | 9	0 0 | 3	57 61 | 63	0 0 | 1
Cortes Bank		0 0 | 2	0 1 | 5	0 0 | 3	11 16 | 18	0
Commercial Shellfish		74 84 | 88	5 19 | 41	24 40 | 63	3 13 | 38	21 63 | 75
General Sportsfishing		54 76 | 85	15 47 | 75	44 65 | 87	36 55 | 73	25 69 | 87

Resource Category

TABLE 8

CONDITIONAL PROBABILITY OF OIL SPILL IMPACT AS A FUNCTION OF TRACTS

Note: Assuming that an oil spill does take place in a given area (P, etc.), the probability of impact is shown within:

top - 3 days
lower left-10 days
lower right-30 days

Note: All numbers indicate probability in percent.

Shoreline Segment	Shoreline Segment No.	Eel River P1	Eel River P2	Pt. Arena P3	Bodega P4	Santa Cruz P5	Santa Cruz P6	Santa Cruz P7	Santa Maria P8	Santa Maria P9	Santa Maria P10	Santa Maria P11	Santa Maria P12
San Mateo County	17	0	0	0 0 | 2	1 13 | 15	2 13 | 19	0 7 | 13	0 5 | 11	0	0	0	0	0
San Mateo County	18	0	0	0 0 | 1	0 2 | 6	1 11 | 12	7 15 | 15	0 1 | 1	0	0	0	0	0
Santa Cruz County	19	0	0	0	0 4 | 10	10 28 | 36	24 46 | 49	2 16 | 23	0	0	0	0	0
San Luis Obispo County	25	0	0	0	0 0 | 1	3 7 | 8	1 3 | 4	4 14 | 19	0	0	0	0	0
San Luis Obispo County	26	0	0	0	0	0	0	0	2 6 | 6	0 2 | 3	0 2 | 4	0 1 | 3	0 1 | 4
Santa Barbara County	27	0	0	0	0	0	0	0	6 9 | 11	0 1 | 2	1 7 | 9	0 1 | 2	0 3 | 7
Farallon Island	15	0	0	0	0	0	0	0	1 4 | 6	0 0 | 1	1 3 | 3	0	0
San Miguel Island	40	0	0	0	0	0	0	0	0 4 | 7	0 7 | 8	0 10 | 11	0 7 | 8	0 13 | 14
Santa Rosa Island	41	0	0	0	0	0	0	0	0	0	0	0	0 0 | 1
Santa Cruz Island	42	0	0	0	0	0	0	0	0	0	0	0	0
Anacapa Island	43	0	0	0	0	0	0	0	0	0	0	0	0
Catalina Island	47	0	0	0	0	0	0	0	0	0	0	0	0
Rodriquez Seamount		0	0	0	0	0	0	0	0 0 | 1	0 1 | 4	0 0 | 1	0 3 | 4	0 1 | 2
Gulf of the Farallons		0	0	0 1 | 3	5 25 | 27	6 25 | 28	2 14 | 17	0 12 | 19	0	0	0	0	0
Sea Otter Range		0	0	0	0 0 | 1	0 0 | 1	0	0 9 | 11	30 34 | 35	1 8 | 13	1 7 | 12	0 4 | 12	0 2 | 9
Richardson Rock		0	0	0	0	0	0	0	0 9 | 14	0 9 | 11	0 15 | 19	0 10 | 12	4 19 | 22
Wilson Rock		0	0	0	0	0	0	0	0 3 | 4	0 6 | 7	0 9 | 9	0 6 | 6	0 10 | 11
Tanner Bank		0	0	0	0	0	0	0	0 0 | 7	0 0 | 11	0 0 | 9	0 0 | 11	0 1 | 10
Cortes Bank		0	0	0	0	0	0	0	0 0 | 10	0 0 | 14	0 0 | 9	0 1 | 15	0 1 | 11
Commercial Shellfish		20 47 | 67	76 83 | 89	49 61 | 66	33 56 | 66	73 76 | 77	70 71 | 72	3 25 | 34	83 89 | 91	41 53 | 65	43 62 | 70	5 26 | 46	4 36 | 54
General Sportsfiahing		100 100 | 100	100 100 | 100	16 21 | 27	37 55 | 69	87 98 | 99	100 100 | 100	30 77 | 89	100 100 | 100	9 31 | 58	79 83 | 89	2 24 | 57	6 36 | 61

Resource Category

TABLE 9

CONDITIONAL PROBABILITY OF OIL SPILL IMPACT AS A FUNCTION OF TRANSPORTATION ROUTE

Note: Assuming that an oil spill does take place within a given tanker/pipeline segment (T_1, etc.) the probability of impact is shown within:

top - 3 days
lower left - 10 days
lower right - 30 days

	Shoreline Segment No.	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28	T29	T30	T31
Shoreline Segment																																
San Mateo County	17	0	0 0 1	0 0 1	0 0 1	0 0 2	5 20 22	60 64 64	2 13 16	0 0 3	4 4 4	0 1 3	0 1 3	0 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Mateo County	18	0	0 0 2	0 0 5	0 1 10	0 6 13	0 12 17	1 8 9	1 20 26	0 10 15	80 84 84	0 8 15	1 5 15	0 1 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santa Cruz County	19	0	0 0 1	0 0 2	0 0 3	0 0 3	0 0 1	0	0 2 4	0 2 4	0	0 4 7	1 4 9	0 2 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Luis Obispo County	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0 1	0 1 3	0 1 2	0 0 1	0 0 1	0 0 1	0	0	0	0	0	0	0	0	0	0	0	0
San Luis Obispo County	26	0	0	0	0	0	0	0	0	0	0	0	0	0 0 1	0 0 1	44 49 50	40 45 45	0 0 1	0 0 2	0 0 2	0	0	0	0	0	0	0	0	0	0 0 1	0	0
Santa Barbara County	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26 29 29	34 36 36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Farallon Island	15	0	0 0 2	0 1 4	0 1 4	1 8 12	3 10 11	0 3 3	13 22 24	3 7 10	0 3 6	1 12 17	0 7 14	0 0 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Miguel Island	40	0	0	0	0	0	0	0	0	0	0	0	0	0 0 3	0 3 8	0 1 1	0 1 1	0 2 6	1 4 5	7 16 17	6 8 9	0	0	0	0	0	0	0 0 1	1 2 2	0 1 1	0 0 1
Santa Rosa Island	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6 11 12	0 2 3	0 0 1	0	0 1 2	0 0 1	0 1 2	0 1 2	0 2 2	1 2 2	0	0 1 3
Santa Cruz Island	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21 30 32	0 3 4	0 0 1	0	0 0 1	0	0 0 1	0 1 2	0 0 1	0	0	6 10
Anacapa Island	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8 11 12	4 9 10	0 1 1	0	0 1 1	0	0 0 1	0 1 2	0 0 1	0	0	17 19
Catalina Island	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0 1	10 20 24	8 18 19	0	50 60 67	4 8 11	0 6 11	20 29 33	0 4 9	0 1 2	0 0 1	0 0 1
Resource Category																																
Rodriquez Seamount		0	0	0	0	0	0	0	0	0	0	0	0	0 7 15	0 13 17	0 0 1	0 0 1	2 17 21	1 5 6	0 3 5	0 0 1	0	0	1 1 3	0	0	0	0 0 1	0 1 1	4 8 11	0
Gulf of the Farallons		0 0 1	0 0 3	0 2 9	0 3 8	6 17 23	10 17 18	1 4 4	30 35 38	10 15 19	1 6 8	3 19 25	0 17 23	0 1 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sea Otter Range		0	0	0 0 1	0 0 1	0 0 2	0	0	0 0 1	0 0 4	0	0 2 6	0 7 9	2 9 12	0 4 10	0 3 5	0 2 3	0 1 9	0 0 6	0 0 4	0 0 1	0	0	0 0 1	0	0	0	0	0	0 1	0 0 1	0 0 4	0
Richardson Rock		0	0	0	0	0	0	0	0	0	0	0	0	0 0 3	0 3 6	0 3 3	0 2 2	0 1 5	9 14 15	22 30 31	7 9 10	0	0	0 1 1	0	0	0	0	0	0 2 2	0 2 2	0 0 1
Wilson Rock		0	0	0	0	0	0	0	0	0	0	0	0	0 0 3	0 3 7	0 1 1	0 1 1	0 2 6	0 2 2	7 11 11	7 9 10	0	0	0	0	0	0	0	0	0	0 1 1	0 0 1
Tanner Bank		0	0	0	0	0	0	0	0	0	0	0	0	0 0 3	0 0 10	0 0 2	0 0 1	0 0 1	0 2 5	0 2 12	0 0 2	0 0 1	0	0 5 13	0 0 1	12 15 18	0 1 5	0 0 2	0 1 6	0 7 16	0 2 17	0
Cortes Bank		0	0	0	0	0	0	0	0	0	0	0	0	0 0 9	0 0 18	0 0 1	0 0 1	0 1 8	0 3 8	0 1 10	0 0 2	0 0 1	0	0 12 20	0 0 2	1 2 4	0 0 2	0 0 1	0 1 4	0 5 13	0 7 24	0
Commercial Shellfish		1 25 43	7 39 47	12 30 42	0 8 23	3 26 44	75 84 87	100 90 100	67 72 76	3 23 39	52 52 53	5 19 32	4 22 32	0 5 26	0 9 24	42 50 62	45 52 57	0 6 12	3 12 15	12 29 43	74 84 88	19 44 65	23 57 73	0 8 21	2 35 47	11 32 58	13 36 60	22 38 56	6 26 52	4 11 34	0 5 28	84 93 97
General Sportsfishing		1 26 48	7 41 53	1 12 20	0 11 34	10 36 58	89 92 95	100 100 100	88 82 89	17 40 60	100 100 100	13 47 67	12 54 71	0 19 44	1 11 44	100 100 100	100 100 100	0 4 23	3 12 29	12 29 53	54 76 85	29 62 87	23 65 85	0 11 33	60 76 91	22 52 79	41 65 87	47 70 90	19 50 80	6 32 62	0 7 45	58 83 90

Note: All numbers indicate probability in percent.

Table 9. To eliminate the less significant numbers and provide data that could more easily be analyzed, any shoreline segment or resource category that showed less than a 5-percent probability of being impacted by an oil spill is not shown. If the less than 5 percent data is desired, it can be obtained from the USGS Report (2). For further simplicity, the shoreline segments as they are listed in the left vertical column, are identified. To aid the reader, since the small scale of the map on Figure 4 precludes any accurate identification of boundary lines, each shoreline segment is further defined in Table 10. The resource categories shown in Figures 5, 6, and 7 (listed on the lower left column of Tables 5, 6, and 7) do not require further defining. As the reader reads to the right on each table, each potential launch point is defined by identification number (P3, E5, T4, etc.), and the area within which it is located. Within each block, there appears three boxes. The top box indicates the probability of impact within 3 days. The lower left box shows the probability of impact within 10 days, and the lower right box, the probability of impact within 30 days. From the time period, as indicated, a feeling can be obtained about the time element for both the weathering process and time to deploy recovery and containment equipment.

Finally, Table 11 shows the worst case probability of impact for each resource by the total proposed Sale No. 53 as a function of the three transportation scenarios. The number in the upper left hand corner of each box shows the oil spill impact probability as a function of Sale No. 53 only. The number in the lower right corner indicates the total

TABLE 10

DEFINITION OF SHORELINE SEGMENTS

Shoreline Segment No. 17 (San Mateo County)

Significant Areas Within Segment:

Point San Pedro, San Francisco, San Francisco Bay, Point Bonita, Golden Gate National Recreation Area

Significant Categories of Impact:

Pinnipeds (Point San Pedro), kelp beds, rocky intertidal areas, sportfishing areas, high intensity use beaches (Sharp Park, Marin Headlands State Park, Montara State Beach, Thorton State Beach, Golden Gate Park, Seal Rocks State Beach, Baker State Beach), Steinhart Aquarium, recreational boating areas, major commercial ports (San Francisco, Oakland Harbor, Richmond Harbor), and known historical sites. Thornton State Beach, Gray Whale Cove, Devils Slide (geohazard)

Shoreline Segment No. 18 (San Mateo County)

Significant Areas Within Segment:

Pescadero Point, Martins Beach, Half Moon Bay, Point Montara

Significant Categories of Impact:

ASBS (James Fitzgerald), Marine Life Refuge (James Fitzgerald), Pescadero Creek, seabird breeding and nesting areas, kelp beds, rocky intertidal areas, sportfishing, high intensity use beaches (Half Moon Bay State Beach, San Gregorio State Beach, Pomponio State Beach, Pescadero State Beach, Bean Hollow State Beach), marina and harbor (Half Moon Bay), recreational boating areas, and known historical sites. Pescadero Marsh, Tunitas Beach, Martin's Beach

Shoreline Segment No. 19 (Santa Cruz County)

Significant Areas Within Segment:

Davenport, Ano Nuevo Bay, Ano Nuevo Island, Point Ano Nuevo, Pigeon Point

Significant Categories of Impact:

ASBS (Ano Nuevo), pinnipeds (Ano Nuevo Island, Ano Nuevo Bay, Pigeon Point), kelp beds, rocky intertidal areas, sportfishing areas, clam beaches (Point Ano Nuevo, Ano Nuevo Bay), high intensity use beaches (Ano Nuevo State Reserve), and known historical sites. Pebble Beach

Shoreline Segment No. 25 (San Luis Obispo County)

Significant Areas Within Segment:

Morro Bay, Cuyucos, Point Estero, Cambria, Morro Bay estuary

Significant Categories of Impact:

Rare and endangered species (American Peregrin Falcon, Morro Bay Kangaroo Rate, Sea Otter), kelp beds, rocky intertidal areas, sportfishing areas, oyster beds (Morro Bay Oyster farm), clam beaches (Morro Bay, Cuyucos), high intensity use

beaches (Cukyucos State Beach, Atascadero State Beach, Morro Strand State Beach, Morro Rock Natural Reserve, Morro Bay State Park), skin and SCUBA diving areas, major commercial port (Morro Bay harbor), recreational boating areas, and known historic sites.

Shoreline Segment No. 26 (San Luis Obispo County)

Significant Areas Within Segment:

Oceano, Pismo Beach, San Luis Obispo Bay, Avila Beach, Point San Luis, Point Buchon

Significant Categories of Impact:

Sensitive biological areas (Dune Lake, Oso Flace Lake, Santa Maria River), Sea bird breeding and nesting areas (Point San Luis, Point buchon), pinnipeds (Point San Luis, Point Buchon), kelp beds, rocky intertidal areas, sportfishing areas, clam beaches (Oceano, Pismo Beach, Avila Beach), high intensity use beaches (Avila State Beach, Montana de Oro State Park, Pismo State Beach), skin and SCUBA diving areas, marinas and harbors, recreational boating areas, and known historic sites.

Shoreline Segment No. 27 (Santa Barbara County)

Significant Areas Within Segment:

Purisima Point, Point Sal, Santa Maria, Guadalupe, Santa Maria

Significant Categories of Impact:

Pinnipeds (Point Sal), rocky intertidal areas, sportfishing areas, high intensity use beaches (Point Sal State Beach), and a known historic site.

Shoreline Segment No. 15 (Farallon Islands) - San Francisco County

Significant Categories of Impact:

ASBS, National Wildlife Refuge, sea bird breeding and nesting area, pinnipeds and sportfishing area.

Shoreline Segment No. 40 (San Miguel Island) - Santa Barbara County

Significant Areas Within Segment:

Richardson Rock, Wilson Rock, Point Bennett, Harris Point, Prince Island, Cardwell Point

Significant Categories of Impact:

ASBS, rare and endangered species (island fox, California least tern), seabird breeding and nesting area, pinnipeds, kelp beds, rocky intertidal areas, sportfishing areas, skin and SCUBA diving area.

Shoreline Segment No. 41 (Santa Rosa Island) - Santa Barbara County

Significant Areas Within Segment:

Carrington Point, East Point, South Point Bee Rock, Sandy Point, Beckers Beach, Cluster Point

Significant Categories of Impact:
ASBS, rare and endangered species (island fox), seabird breeding and nesting area, pinnipeds, kelp beds, rocky intertidal areas, sportfishing areas, skin and SCUBA diving areas, recreational boating area.

Shoreline Segment No. 42 (Santa Cruz Island) - Santa Barbara County
Significant Areas Within Segment:
West Point, Diablo Point, Chinese Harbor, San Pedro Point, Bowen Point, Gull Island, Kinto Point
Significant Categories of Impact:
ASBS, rare and endangered species (Island fox), seabird breeding and nesting area, pinnipeds, kelp beds, rocky intertidal areas, sportfishing areas, skin and SCUBA diving areas, and a recreational boating area.

Shoreline Segment No. 43 (Anacapa Island) - Ventura County
Significant Categories of Impact:
ASBS, rare and endangered species (California Brown Pelican), seabird breeding and nesting area, pinnipeds, kelp beds, rocky intertidal areas, sportfishing area, skin and SCUBA diving area, recreational boating area and a known historical site.

Shoreline Segment No. 47 (Catalina Island) - Los Angeles County
Significant Areas Within Segment:
West end, Isthmus Cove, Long Point, Avalon, Little Harbor, Catalina Harbor, Farnsworth Bank
Significant Categories of Impact:
ASBS, ecological reserve (Farnsworth Bank, Lovers Cove), rare and endangered species (Island fox), seabird breeding and nesting area, pinnipeds, kelp beds, rocky intertidal areas, sportfishing area, skin and SCUBA diving area, marina and harbor (Avalon and Isthmus Cove), USC Marine Laboratory.

TABLE 11

PROBABILITY OF OIL SPILL IMPACT AS
A FUNCTION OF OCCURRENCE

		Transportation Scenario No. 1	Transportation Scenario No. 2	Transportation Scenario No. 3
Shoreline Segment	Shoreline Segment No.			
San Mateo County	17	6 / 9	13 / 16	
San Mateo County	18	20 / 24	21 / 25	8 / 13
Santa Cruz County	19		5 / 8	
San Luis Obispo County	25	6 / 6		
San Luis Obispo County	26	21 / 22	5 / 6	
Santa Barbara County	27	15 / 15		
Farallon Island	15	8 / 13	10 / 15	
San Miguel Island	40	11 / 34	14 / 36	8 / 32
Santa Rosa Island	41		9 / 42	
Santa Cruz Island	42		19 / 73	
Anacapa Island	43		11 / 48	
Catalina Island	47		12 / 57	
Resource Category				
Rodriquez Seamount			7 / 19	8 / 19
Gulf of the Farallons		12 / 19	14 / 22	7 / 15
Sea Otter Range		22 / 29	17 / 25	16 / 24
Richardson Rock		17 / 41	19 / 42	12 / 37
Wilson Rock		8 / 34	12 / 37	6 / 33
Tanner Bank		12 / 41	12 / 41	17 / 44
Cortes Bank		15 / 32	15 / 32	24 / 39
Commercial Shellfish		76 / 100	88 / 100	60 / 100
General Sportsfishing		84 / 100	91 / 100	68 / 100

Note: Upper left corner shows worst case (30 day) Sale No. 53 impact probability.

Lower right corner shows combined impact (30 day) of Sale No. 53 plus other projected oil transport related activities.

	No. 1	No. 2	No. 3
Shoreline Segment No.			
17	2 / 5 / 6 / 13	8 / 13	
18	10 / 17 / 20	7 / 18 / 21	3 / 7 / 8
19		1 / 4 / 5	
25	1 / 3 / 6		
26	15 / 19 / 21	1 / 3 / 5	
27	12 / 14 / 15		
15	1 / 5 / 8	1 / 6 / 10	
40	0 / 9 / 11	4 / 12 / 14	0 / 6 / 8
41		3 / 7 / 9	
42		12 / 17 / 19	
43		6 / 10 / 11	
47		5 / 10 / 12	
Resource Category			
Rodriquez Seamount		0 / 4 / 7	1 / 5 / 8
Gulf of the Farallons	3 / 9 / 12	3 / 12 / 14	1 / 5 / 7
Sea Otter Range	9 / 16 / 22	6 / 11 / 17	6 / 11 / 16
Richardson Rock	0 / 14 / 17	6 / 16 / 19	0 / 9 / 12
Wilson Rock	0 / 8 / 8	4 / 11 / 12	0 / 5 / 6
Tanner Bank	0 / 0 / 12	0 / 1 / 12	0 / 4 / 17
Cortes Bank	0 / 0 / 19	0 / 1 / 19	0 / 9 / 24
Commercial Shellfish	62 / 71 / 76	75 / 83 / 88	37 / 49 / 60
General Sportsfishing	72 / 79 / 84	75 / 86 / 91	38 / 53 / 68

Note: Top number indicates probability of oil spill impact within 3 days.

Lower left indicates probability of oil spill impact within 10 days.

Lower right indicates probability of oil spill impact within 30 days.

Note: All numbers indicate probability in percent.

cumulative probability of Sale No. 53 and other projected activities such as imported oil being tankered in, etc.

Conclusions cannot be made about the data presented in this paper as it only represents the modeling effort for oil spill trajectories and shows predicted locations and categories of impact. This information must be evaluated by each analyst on the respective shoreline or resource category before conclusions can be drawn.

References

1. Lanfear, K. J., R. A. Smith and J. R. Slack. "An Introduction to the Oil Spill Risk Analysis Model," Proceedings of the 1979 OTC Conference, pp. 2173-2181.

2. Samuels, William B. and Kenneth J. Lanfear. "An Oil Spill Risk Analysis for the Central and Northern California (Proposed Sale No. 53) Outer Continental Shelf Lease Area," 1980, U.S. Geological Survey Open-File Report 80-211.

3. Bureau of Land Management. "Final Environmental Impact Statement for OCS Oil and Gas Sale No. 48," 1979.

4. Wyllie, John G. "Geostrophic Flow of the California Current at the Surface and at 200 Meters." California Cooperative Oceanic Fisheries Investigations, Atlas No. 4, Dec. 1966.

5. Kolpack, Ronald L. "Oceanography of the Santa Barbara Channel, Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970." Vol. II, Chapter 4. pp. 90-115. Allan Hancock Foundation, USC. 1971.

6. Bernstein, Robert L., L. Breaker and R. Whritner. "California Current Eddy Formation: Ship, Air and Satellite Results." Science 1-28-77, Vol. 195, No. 4276, pp. 353-359.

7. Blaskovich, David D. "A Drift Card Study in Monterey Bay, California: Sept. 1971 to April 1973." Tech. Pub. 73-4, Moss Landing Marine Laboratories Annual Report, Part 4, 1973. 79 p.

8. California State Water Quality Control Board. "An Oceanographic and Biological Survey of the Southern California Mainland Shelf." Publication No. 27, 1965.

9. Crowe, Fred J. and R. A. Schwartzlose. "Release and Recovery Records of Drift Bottles in the California Current Region, 1955-1971." CALCOFI Atlas No. 16, June 1972.

10. Hamby, R. J. "Drift Bottle Studies at Bodega Head, California." Pacific Marine Station, University of the Pacific.

11. Jones, James H. "General Circulation and Water Characteristics in the Southern California Bight." Southern California Coastal Water Research Project - TR 101, Oct. 1971.

12. Changery, M. J., W. T. Hodge and J. V. Ramsdell. "Index-Summarized Wind Data," Battelle Pacific Northwest Laboratories, BNWL-2220 WIND-11, UC-60, Sept. 1977.

13. U.S. Naval Weather Service Command. "Summary of Synoptic Meteorological Observations, North American Coastal Marine Areas-Revised." Vols. 5 and 6, May 1976.

14. Bureau of Land Management. "Final Environmental Impact Statement for OCS Oil and Gas Sale No. 35," 1975.